# MIOSPORES FROM THE LOWER CARBONIFEROUS BASEMENT BEDS IN THE MENAI STRAITS REGION OF CAERNARVONSHIRE, NORTH WALES

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ABSTRACT. A well-preserved miospore flora from the Basement Beds of the Lower Carboniferous in the Menai Straits region of Caernarvonshire, North Wales is described. A total of 47 species is recorded from the deposits. One new genus *Umbonatisporites*, and 7 new species are proposed. The assemblage contains spores characteristic of both Tournaisian and Viséan deposits, but is considered to be Viséan in age.

THE Lower Carboniferous succession throughout North Wales consists largely of a series of limestones underlain by Basement Beds and resting unconformably on Lower Palaeozoic rocks. Lower Carboniferous deposits outcrop on both sides of the Menai Straits and in Caernarvonshire lie on Ordovician rocks. Greenly (1928) described conglomeratic sandstones, shales and thin limestones which he placed at the base of the Lower Dibunophyllum zone ($D_1$). There is a fragmentary fauna, mainly of brachiopods; the lowest horizon containing abundant faunal remains lies close to the base of the overlying Brown Limestone. There is no clear indication of the precise age of the Basement Beds and they have been variously assigned to the base of the $D_1$ or the top of the $S_2$ (Greenly 1928, Neaverson 1946, George 1958).

Three samples were taken from a lenticle of shale, approximately 40 yards long and 3 ft. in thickness, where the Basement Beds outcrop by the Britannia Tubular Bridge on the Caernarvonshire side of the Menai Straits (Grid Ref. SH541708).

Plant remains from these beds were first described by Walton in Greenly (1928), the list of species later being extended by Lacey (1952 *a*, *b*). The later work indicated the presence of a rich assemblage of plant micro-fossils and seeds.

The three samples were collected from the shale in the following ascending order: sample LC2 from the base of the shale outcropping on the foreshore; sample LC3 one foot above LC2 and associated with the plant bed described by Walton and Lacey; LC4 at the top of the shale band two feet above LC3. The three samples showed no marked differences in miospore content and are accordingly treated as one assemblage, characteristic of the Basement Beds.

*Preparation of samples.* The samples were immersed in 40% hydrofluoric acid at 40 °C for up to four days, to remove the silicates. The residue was oxidized in fuming nitric acid for up to two hours, then washed with progressively more dilute nitric acid and transferred to a sinter-glass Buchner funnel. Here the residue was further washed with a 5% solution of potassium hydroxide and then, repeatedly, with distilled water using the technique described by Neves and Dale (1963).

Permanent slides were made using 'Cellosize with a thermosetting plastic as a mountant (Jeffords and Jones 1959).

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The terminology used is that outlined by Couper and Grebe (1961) and expanded by Smith and Butterworth (1967). The classification of the dispersed miospores follows the scheme first proposed by Dettmann (1963) as revised and extended by Smith and Butterworth (1967).

Only those species which are described for the first time, or are considered to be more critical to the present study, are given systematic treatment. In addition to the illustrations using the transmitted light microscope, a number of photographs are reproduced using the scanning reflection electron microscope developed by Cambridge Scientific Instruments following the technique described by Hibbert (1967).

The slides containing holotypes and other figured specimens have been deposited in the School of Plant Biology, University College of North Wales. They are marked with the preparation number and the co-ordinates are those of the Leitz Laborlux microscope no. 582096 of the above Department. Single grain mounts bear the prefix MS.

## SYSTEMATIC DESCRIPTIONS

Anteturma SPORITES H. Potonié 1893
Turma TRILETES (Reinsch) Dettmann 1963
Suprasubturma ACAVATITRILETES Dettmann 1963
Subturma AZONOTRILETES (Luber) Dettmann 1963
Infraturma LAEVIGATI (Bennie and Kidston) Potonié 1956
Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

*Type species. P. punctatus* Ibrahim 1933.

### *Punctatisporites irrasus* Hacquebard 1957

Plate 78, fig. 1

*Description.* Diameter 58–89 $\mu$, mean 74 $\mu$ (45 specimens); amb circular to sub-circular. Laesura distinct, straight, length one-half to three-quarters spore radius, occasionally low lips are developed. Frequently the laesura are gaping with dark intertectal areas.

*Remarks.* Spores with dark intertectal areas were included in this species by Sullivan (1964*a*). It is thought to be a miospore characteristic of Tournaisian assemblages (Sullivan 1967).

*Previous records.* Horton Bluff (Tournaisian) Canada (Hacquebard 1957). Lower Limestone Shales (Tournaisian) Forest of Dean Gloucestershire (Sullivan 1964a). Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968). Springer formation (Mississippian/Pennsylvanian boundary) of Oklahoma (Felix and Burbridge 1967).

Infraturma APICULATI (Bennie and Kidston) R. Potonié 1956
Subinfraturma GRANULATI Dybova and Jachowicz 1957
Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp 1954

*Type species. G. granulatus* Ibrahim 1933.

*Granulatisporites visensis* sp. nov.

Plate 78, fig. 4

*Holotype.* Slide LS9b, 57.2 104.9. Size 41 $\mu$.

*Diagnosis.* Diameter 26–51 $\mu$, mean 37 $\mu$ (56 specimens); amb subtriangular with concave interradial margins and rounded apices. Laesura simple, straight, length from three quarters to equal the spore radius. Ornamentation consists of grana 1·5–4·0 $\mu$ wide at the base and up to 2·0 $\mu$ high; the grana may coalesce to form short, verrucate ridges. Ornament well developed at the apices where it forms an indented margin; the interradial margins mostly smooth. The grana are most strongly developed on the distal surface and are frequently concentrated at the distal pole and along the triangular radii. Exine punctate between the grana.

*Remarks.* The development of irregular ridges characterises this species; its development is not strong enough to warrant different generic assignment.

Subinfraturma VERRUCATI Dybova and Jachowicz 1957
Genus VERRUCOSISPORITES (Ibrahim) Smith and Butterworth 1967

*Type species. V. verrucosus* Ibrahim 1932.

*Verrucosisporites eximius* Playford 1962

Plate 78, figs. 9, 10

*Remarks.* The present specimens show a larger size from 62 to 92 $\mu$, mean 82 $\mu$ than those described by Playford (mean 72 $\mu$); otherwise they are similar.

*Previous records.* Lower Carboniferous of Spitsbergen (Playford 1962, 1963*a*).

Subinfraturma NODATI Dybova and Jachowicz 1957
Genus WALTZISPORA Staplin 1960

*Type species. W. lobophora* (Waltz) Staplin 1960.

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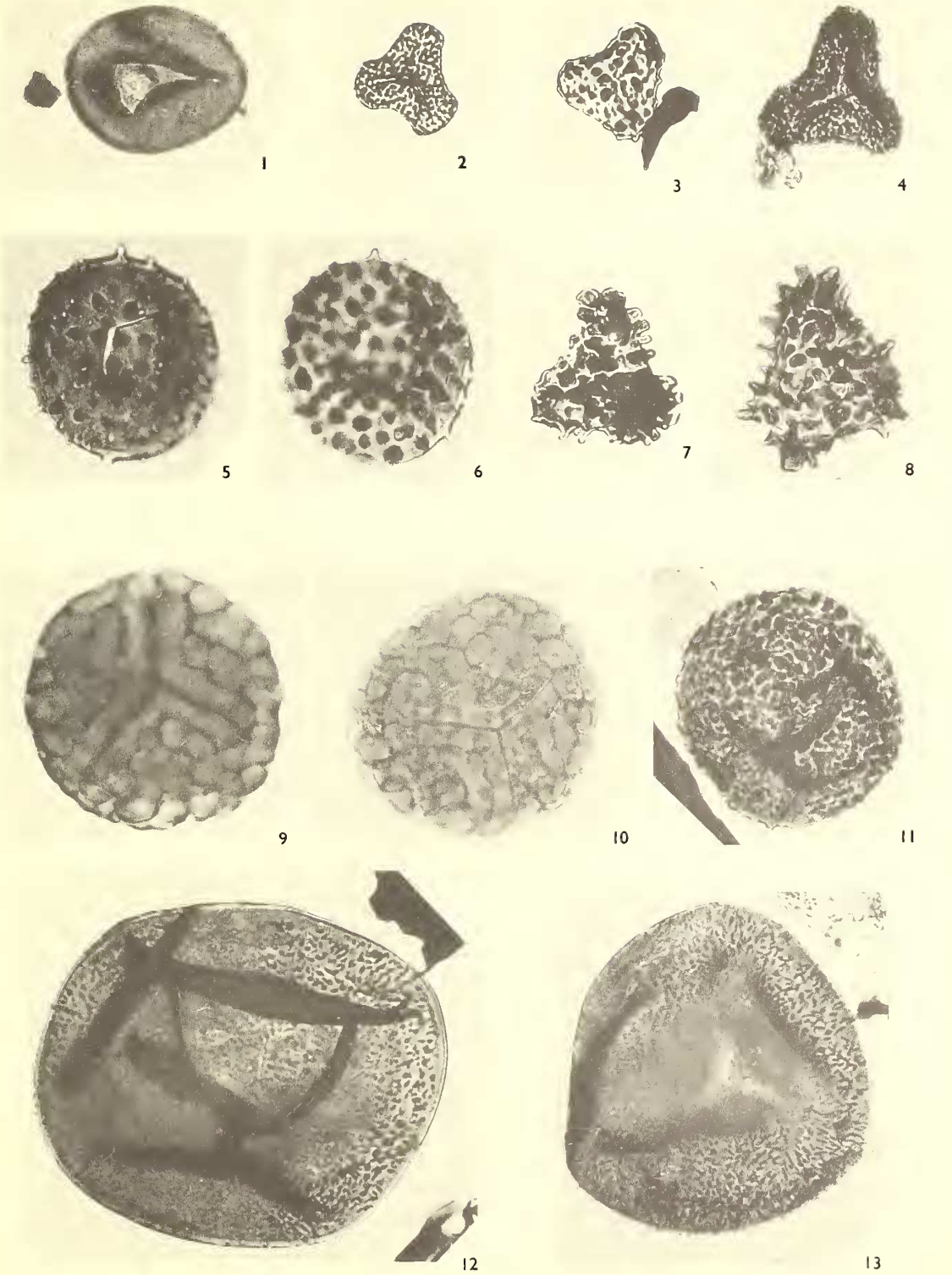
EXPLANATION OF PLATE 78

All figures ×500

Fig. 1. *Punctatisporites irrasus* Hacquebard 1957; Slide LC5b, 21·3 110·0.
Fig. 2. *Waltzispora planiangulata* Sullivan 1964; Slide LC2e, 41·4 101·7.
Fig. 3. *Lophotriletes tribulosus* Sullivan 1964; Slide LC9b, 33·3 95·4.
Fig. 4. *Granulatisporites visensis* sp. nov., Holotype; Slide LC9b, 57·2 104·9.
Figs. 5–6. *Raistrickia nigra* Love 1960; slide MS80. 5, proximal surface. 6, distal surface.
Figs. 7–8. *Neoraistrickia drybrookensis* Sullivan 1964. 7, slide LC2b, 23·0 100·2. 8, slide MS14.
Figs. 9–10. *Verrucosisporites eximius* Playford 1962. 9, proximal surface; slide MS144. 10, proximal surface; slide MS182.
Fig. 11. *Grumosisporites verrucosus* (B. and W.) Smith and Butterworth 1967; LC2c, 32·9 98·5.
Figs. 12–13. *Umbonatisporites variabilis* gen. et sp. nov. 12, distal surface; slide LC2c, 14·6 106·8 13, Holotype, proximal surface; slide LC2e, 44·0 99·0.




HIBBERT and LACEY, Early Carboniferous miospores

*Waltzispora planiangulata* Sullivan 1964

Plate 78, fig. 2

*Description.* Diameter 30–41 $\mu$, mean 35 $\mu$ (50 specimens); amb triangular with bluntly rounded apices, having angular junctions with the concave, interradial margins. Laesura distinct, simple, straight, length from three-quarters to equal to spore radius. Exine 1·0–1·5 $\mu$ thick, ornamented with grana and coni, 0·5 $\mu$ high and 1·0–1·5 $\mu$ in basal diameter; ornament absent from the proximal contact area.

*Remarks.* The variation in ornament between the specimens was not as evident as Sullivan describes. The angular junction between the apex and the concave side was variable but never approaches the distinct angularity described by Staplin (1960) for *W. lobophora.*

*Previous records.* Drybrook Sandstone (Viséan) Forest of Dean Basin, Gloucestershire (Sullivan 1964*b*).

Genus LOPHOTRILETES (Naumova) Potonié and Kremp 1954

*Type species. L. gibbosus* (Ibrahim) Potonié and Kremp 1954.

*Lophotriletes tribulosus* Sullivan 1964

Plate 78, fig. 3

*Remarks.* The size range, diameter 28–39 $\mu$, mean 32 $\mu$ (40 specimens), varies from that originally given by Sullivan (30–45 $\mu$, mean 36·5 $\mu$). Otherwise the range of ornament in the present specimens agrees with the original description.

*Previous records.* Drybrook Sandstone (Viséan) Forest of Dean Basin, Gloucestershire (Sullivan 1964*b*).

Genus UMBONATISPORITES gen. nov.

*Type species. U. variabilis sp. nov.*

*Diagnosis.* Radial, trilete miospores, amb circular to sub-circular. Laesura simple, straight, one sixth of the spore radius; frequently indistinct. Ornament of variable shape, predominantly narrow at the base, widening towards the apex and terminating in a rounded head, which is topped by a short, sharply tapering spine. There may be from one to three rounded 'heads' on the apex of the element (text-fig. 1). There are tapering spines interspersed over the surface of the spore. Exine is frequently folded.

*Umbonatisporites variabilis* sp. nov.

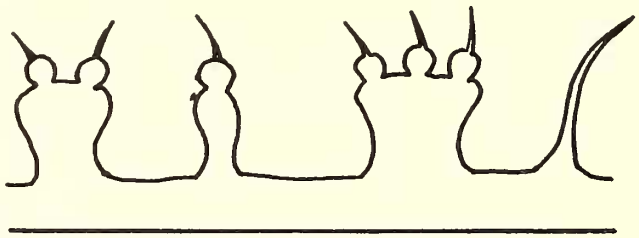
Plate 78, figs. 12, 13; Plate 79, figs. 1–3

*Holotype.* Slide LC2e, 44·4 90·0. Size 120 $\mu$.

*Diagnosis.* Diameter 95–134 $\mu$, mean 106 $\mu$ (34 specimens); amb sub-circular to circular. Laesura one-sixth spore radius, simple, frequently indistinct. Exine 1–2 $\mu$ thick, covered

with a distinctive ornament arranged in indiscriminate patterns. Ornament variable in both size and shape; one element up to 4·5 $\mu$ high and 1·0–1·5 $\mu$ in basal diameter, widening towards the apex where it terminates in a rounded head which is topped with a thin tapering spine. There may be from one to three rounded projections at the apex of the element. These elements are interspersed with spines 0·5–1·0 $\mu$ at the base and from 2·0 to 4·0 $\mu$ long. The exine is commonly folded.

*Remarks.* The only other spore showing variable branching at the apex of the elements making up the ornament is the megaspore *Singhisporites* (Potonié 1956), 'die terminal ± kleine Verzweigungen aufweisen'. There is no indication of the short terminal spine seen in *Umbonatisporites* nor of tapering spines interspersed with the 'bacula'. The ornament in *Singhisporites* is frequently adpressed on to the spore body as is typical of *Umbonatisporites* (Pl. 79, figs. 2, 3).



TEXT-FIG. 1. Profile view of sculpture of *Umbonatisporites variabilis* gen. et. sp. nov.

Subinfraturma BACULATI Dybova and Jachowicz 1957

Genus RAISTRICKIA (Schopf, Wilson, and Bentall) Potonié and Kremp 1954

*Type species. R. grovensis* Schopf 1944.

*Raistrickia nigra* Love 1960

Plate 78, figs. 5, 6

*Remarks.* The size range of the present specimens, from 48 to 67 $\mu$, mean 56 $\mu$ (33 specimens) is smaller than that given by Love, the bacula are also of a smaller dimension. Love comments that his description is based on only a small number of specimens and it is considered that the present material represents an extension of his original description. The sizes do not differ markedly from those given by Sullivan and Marshall (1966).

*Previous records.* Lower Oil Shale group (Viséan) of Scotland (Love 1960). Upper Sedimentary Group (Viséan) of Scotland (Sullivan and Marshall 1966).

*Raistrickia* cf. *clavata* (Hacquebard) Playford 1963

Plate 79, figs. 4, 5

*Description.* Diameter 34–128 $\mu$, mean 109 $\mu$ (30 specimens); amb circular. Laesura straight, length two-thirds to three-quarters the spore radius, with slight lip development. Exine 3·0–6·0 $\mu$ thick (excluding ornament) covered with a variable ornament

of verrucae, mushroom-shaped processes and bacula; their basal diameter varies from 5·5 to 8·0 $\mu$ and height from 2·0 to 9·0 $\mu$. The ornament is irregular and occurs on both faces of the spore.

*Remarks.* The character and positioning of the ornament in *R. clavata* (Hacquebard) Playford 1963) is very similar to the present specimens. The size, however, is that of *R. ponderosa* Playford 1963, which has less verrucae and a more uniform ornament.

### Genus NEORAISTRICKIA Potonié 1956

*Type species. N. truncatus* (Cookson) Potonié 1956.

### *Neoraistrickia drybrookensis* Sullivan 1964

Plate 78, figs. 7, 8

*Description.* Diameter 31–53 $\mu$, mean 45 $\mu$ (35 specimens); amb triangular with rounded apices and straight to slightly concave, or convex sides. Laesura often indistinct, straight, length three-quarters of spore radius; slight lip development. The distal face of the spore is ornamented with cones, bacula, and verrucae. The coni are often blunt, up to 3·0 $\mu$ in height and 4·0 $\mu$ in basal diameter; the bacula are up to 9·0 $\mu$ high and 5·0 $\mu$ in basal diameter and the verrucae from 3·0 to 7·0 $\mu$ high and up to 9·0 $\mu$ in basal diameter. Exine 2·0–2·5 $\mu$ thick.

*Remarks.* The specimens agree closely with the description given by Sullivan; the size range is extended. The large verrucae when occurring on the equator, in particular towards the triangular apices, give the impression that the spore has a flange.

*Previous records.* Drybrook Sandstone (Viséan) Forest of Dean Basin, Gloucestershire (Sullivan 1964*b*).

### Infraturma MURORNATI Potonié and Kremp 1954
### Genus CONVOLUTISPORA Hoffmeister, Staplin, and Malloy 1955

*Type species. C. florida* Hoffmeister, Staplin, and Malloy 1955.

### *Convolutispora labiata* Playford 1962

Plate 79, figs. 8, 9

*Remarks.* Diameter 47–89 $\mu$, mean 64 $\mu$ (50 specimens). The size of the miospores from the Basement Beds is considerably smaller than those described by Playford, diameter 82–114 $\mu$, mean 99 $\mu$. Apart from size difference the present specimens have the same characteristics as Playford originally described and they are therefore placed in *C. labiata.*

*Previous records.* Lower Carboniferous of Spitsbergen (Playford 1962).

### *Convolutispora vermiformis* Hughes and Playford 1961

Plate 79, figs. 6, 7

1957 *Convolutispora flexuosa* forma *minor* Hacquebard, p. 312; pl. 2, fig. 10.

*Remarks.* A number of the present specimens have lower, more insignificant muri than was originally described by Hughes and Playford. They form a continuous morphological series to the more typical form and were all included under *C. vermiformis.*

*Previous records.* Lower Carboniferous of Spitsbergen (Hughes and Playford 1961, Playford 1962). Horton Group (Tournaisian) of Canada (Hacquebard 1957, Playford 1963). Upper Devonian of Melville Island (McGregor 1960). Springer formation (Mississippian/Pennsylvanian boundary) of Oklahoma (Felix and Burbridge 1967).

## Genus DICTYOTRILETES (Naumova) Smith and Butterworth 1967

*Type species. D. bireticulatus* (Ibrahim) Potonié and Kremp 1954.

### *Dictyotriletes tesselatus* sp. nov.

Plate 80, figs. 1, 2, 4, 5, 7, 8

*Holotype.* Slide LC3a, 55·7 93·2. Size 95 $\mu$.

*Diagnosis.* Diameter 78–105 $\mu$, mean 91 $\mu$ (50 specimens); amb circular to sub-circular. Laesura distinct, straight, length from three-quarters to equal to the spore radius; accompanied by prominent lips up to 6·0 $\mu$ broad on each side of the mark, having a number of blunt crests up to 5·0 $\mu$ high. Ornamentation on both faces of the spore of smooth muri, 2·5–4·0 $\mu$ wide and up to 11·0 $\mu$ high, frequently with a clavate profile when seen equatorially. The muri are frequently expanded where they anastamose, and may terminate abruptly on the proximal face. Lumina very irregular in shape, from 5·0 to 27·0 $\mu$ in longest diameter, there may be clavate projections within them. Exine 2·5 to 4·0 $\mu$ thick (excluding ornament).

*Comparison. Reticulatisporites variolatus* Playford 1962 is characterized by a higher frequency of more clavate muri when seen in profile. The lumina are more regularly arranged and are rounded to polygonal in shape; the exine is also thicker and the laesura is not accompanied by lips. *R. cancellatus* Playford 1962 has lower muri which are not clavate in section.

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EXPLANATION OF PLATE 79

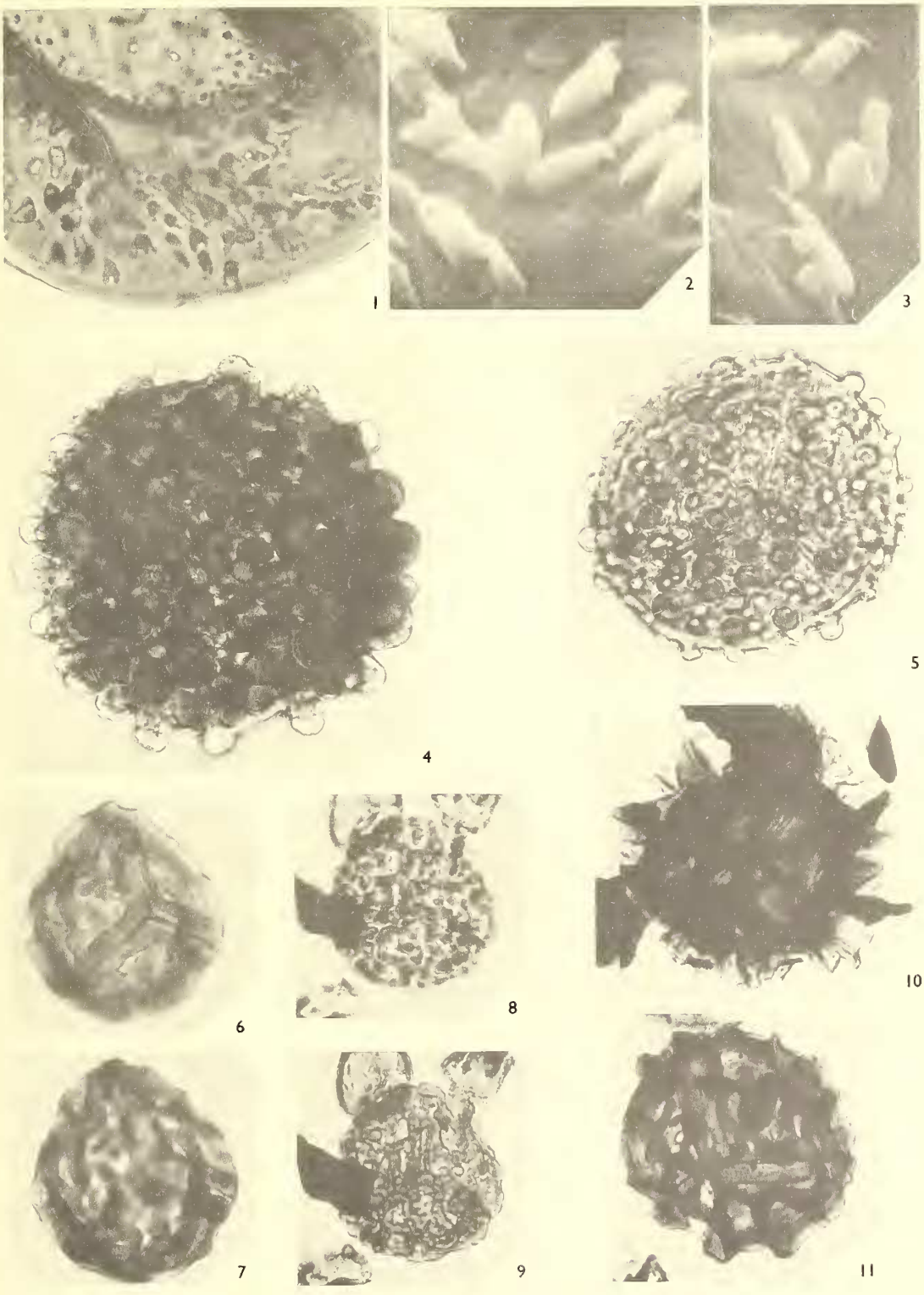
All figures $\times$500 unless otherwise stated

Figs. 1–3. *Umbonatisporites variabilis* gen. et sp. nov. 1, Details of ornament; slide LC2c, 14·6 106·8; $\times$1000. 2, 3, Stereoscan pictures showing detail of ornament. 2, negative S/28/32, $\times$5650. 3, negative S/28/37, $\times$5650.

Figs. 4–5. *Raistrickia* cf. *clavata* (Hacquebard) Playford 1963. 4, Distal surface; slide MS174. 5, Proximal surface; slide MS177.

Figs. 6–9. *Convolutispora* spp. 6–7, *C. vermiformis* Hughes and Playford 1961; Slide MS153. 6, Proximal surface. 7, Distal surface. 8–9, *C. labiata* Playford 1962; Slide LC3a, 32·8 96·2. 8, Distal surface. 9, Proximal surface.

Figs. 10–11. *Dictyotriletes* spp. 10, *D. pactilis* Sullivan and Marshall 1966; Slide LC5c, 16·5 106·7. 11, *D. cancellatus* Playford 1962. Proximal surface, slide LC3d, 37·8 110·9.

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*Dictyotriletes cancellatus* (Waltz) Potonié and Kremp 1955

Plate 79, fig. 11

1938 *Azonotriletes cancellatus* Waltz, in Luber and Waltz, p. 11; pl. 1, fig. 8 and pl. 5, fig. 73.
1955 *Sphenophyllotriletes cancellatus* (Waltz) Luber, pp. 41–2, pl. 4, figs. 78*a*, *b*, 79.
1955 *Dictyotriletes cancellatus* (Waltz) Potonié and Kremp, p. 108.
1956 *Dictyotriletes cancellatus* (Waltz) Ishchenko, p. 43; pl. 7, figs. 88, 89.
1957 *Dictyotriletes cancellatus* (Waltz) Naumova; Kedo, p. 1166.
1957 *Reticulatisporites varioreticulatus* Hacquebard and Barss, p. 17, pl. 2, figs. 15, 16.
1962 *Reticulatisporites cancellatus* (Waltz) Playford, pp. 597–8; pl. 82, figs. 11–13 and pl. 83, figs. 1, 2.

*Remarks.* The inclusion of this species within the genus *Dictyotriletes* follows the emendation of *Reticulatisporites* by Neves (1964) and the subsequent emendation of *Dictyotriletes* by Smith and Butterworth (1967). In the comparison of their new genus *Corbulispora* with *Dictyotriletes* Bharadwaj and Venkatachala (1962) separate the two on the basis of the latter having 'flat muri . . . a simple trilete mark' (p. 24). There is no valid reason for emphasizing the simple trilete mark as an important difference between the two and it would seem that the interpretation of flat muri is not objective. It would seem that these characteristics are not of sufficient significance to separate the two genera. A more detailed study of the type material is needed to resolve the problem.

*Previous records.* Lower Carboniferous of the U.S.S.R. (Waltz in Luber and Waltz 1938, Luber 1955, Ishchenko 1956, 1958 and Kedo 1957, 1958). Lower Carboniferous of Canada (Hacquebard and Barss 1957) and of Spitsbergen (Playford 1962).

*Dictyotriletes pactilis* Sullivan and Marshall 1966

Plate 80, fig. 10

*Description.* Diameter 62–105 $\mu$, mean 85 $\mu$ (50 specimens); amb circular to subcircular. Laesura not seen. Ornament of thin, tall muri 0·5 to 2·0 $\mu$ wide and up to 18·0 $\mu$ high, clearly visible as radial projections at the equator. Lumina irregular in shape, from 5·0 to 33·0 $\mu$ in longest diameter. Muri frequently folded. Exine 2·0 to 4·0 $\mu$ thick.

*Remarks.* In measuring eleven specimens Sullivan and Marshall gave a size range of 52–63 $\mu$, mean 58 $\mu$. On the basis of a greater number of specimens this size range is extended. *Reticulatisporites* sp. B recorded by Love (1960) would seem to be *D. pactilis*. Love records a size of 74 $\mu$ for his specimen.

*Previous records.* Lower Oil Shale group (Viséan) of Scotland (Love 1960). Upper Sedimentary Group (Viséan) of Scotland (Sullivan and Marshall 1966). Goddard formation (upper Mississippian) of Oklahoma (Felix and Burbridge 1967).

*Dictyotriletes submarginatus* Playford 1963

Plate 80, figs. 3, 6, 11, 12.

*Description.* Diameter 52–69 $\mu$, mean 60 $\mu$ (25 specimens); amb sub-triangular. Laesura distinct, sinuous or straight, extending to the equator, accompanied by elevated lips up to

3 $\mu$ wide. Proximal surface laevigate, occasionally the muri run on to the proximal surface in the equatorial region. Distal surface ornamented with low, narrow, sinuous muri, which may both anastamose and terminate freely; the lumina formed are irregular in shape. Equatorial outline irregular to deeply indented.

*Remarks.* The spores described here agree closely with the original description given by Playford, with the exception that the ornament of the distal surface appears to be less dense and the incisions at the equator are deeper than his figured specimens. It is not clear if the equatorial structure is a true cingulum, or is a feature produced by the fusion of muri.

*Previous records.* Horton Group (Tournaisian) of Canada (Playford 1963).

Subturma ZONOTRILETES Waltz 1935
Infraturma CINGULATI (Potonié and Klaus) Dettmann 1963
Genus KNOXISPORITES (Potonié and Kremp) Neves and Playford 1961

*Type species. K. hageni* Potonié and Kremp 1954.

*Knoxisporites stephanophorus* Love 1961

Plate 80, figs. 9, 10

*Remarks.* Diameter 46–84 $\mu$, mean 68 $\mu$ (20 specimens). The distal thickenings and distinctive structure of the lips, thinning proximally, are characteristic of this species.

*Previous records.* Lower Oil Shale group (Viséan) of Scotland (Love 1960). Upper Sedimentary group (Viséan) of Scotland (Sullivan and Marshall 1966). Springer formation (Mississippian/Pennsylvanian boundary) and Goddard formation (Upper Mississippian) of Oklahoma (Felix and Burbridge 1967).

*Knoxisporites pristinus* Sullivan 1968

Plate 81, figs. 5, 6, 9

*Description.* Diameter 53–89 $\mu$, mean 68 $\mu$ (27 specimens); amb circular to sub-circular, frequently irregular. Laesura distinct, length from three-quarters to almost equal to

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EXPLANATION OF PLATE 80

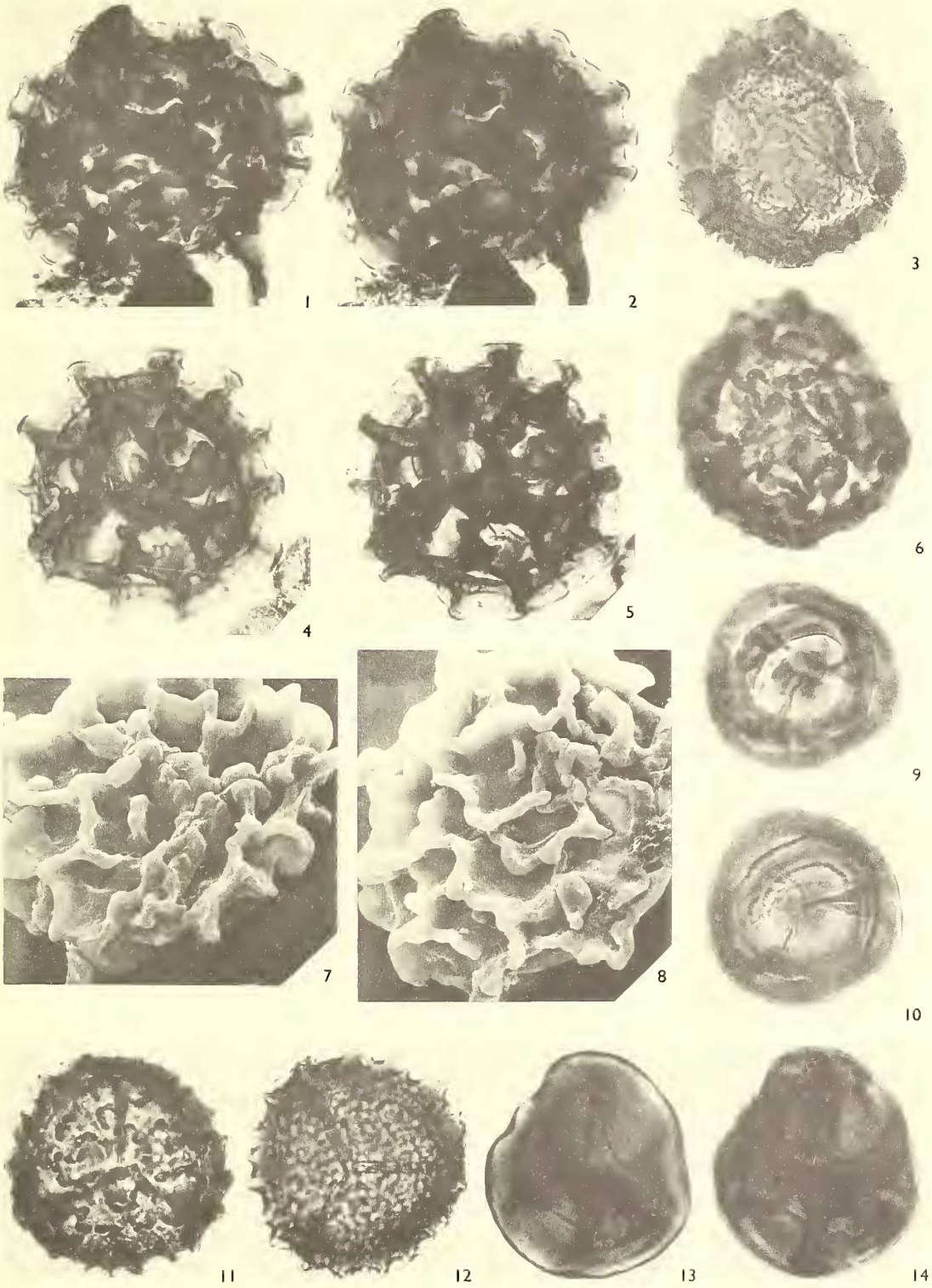
All figures $\times$ 500 unless otherwise stated

Figs. 1, 2, 4, 5, 7, 8. *Dictyotriletes tesselatus* sp. nov. 1, Holotype, distal surface; slide LC3a, 55·7 93·2. 2, Holotype, proximal surface, 4, Proximal surface; slide LC3c, 31·0 99·8 5, Distal surface; slide LC3c, 31·0 99·8 7, Stereoscan, proximal surface; negative S/26/40, $\times$600. 8, Stereoscan, distal surface; negative S/26/29, $\times$630.

Figs. 3, 6, 11, 12. *Dictyotriletes submarginatus* Playford 1963. 3, Proximal surface; slide MS122. 6, Distal surface; slide MS122. 11, Distal surface; slide MS81. 12, Proximal surface; slide MS81.

Figs. 9, 10. *Knoxisporites stephanophorus* Love 1961; Slide MS108. 9, Distal surface. 10, Proximal surface.

Figs. 13, 14. *Knoxisporites seniradiatus* Neves 1961; Slide MS91. 13, Proximal surface. 14, Distal surface.

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the radius of the central body, occasionally lips are developed. Exine thickened on the distal surface, the thickenings are irregular in shape and frequently only slightly developed.

*Remarks.* The present specimens clearly fit into the description given by Sullivan. The variability and often ill-defined nature of the thickenings make it likely that many spores which are rather badly preserved will be placed in this species. Certainly some of the present material approximates to *K. hederatus* (Ishchenko) Playford 1963 and *K. rotatus* Hoffmeister, Staplin, and Malloy 1956.

*Previous records.* Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968).

*Knoxisporites seniradiatus* Neves 1961

Plate 80, figs. 13, 14

*Remarks.* Although very few specimens of this spore were seen, they were clearly referable to this species; the laesura having wide, prominent lips, so distinguishing the specimens from *K. triradiatus* Hoffmeister, Staplin, and Malloy 1955. Sullivan (1964a) records *K.* cf. *triradiatus* from Tournaisian deposits; in these specimens the trilete has narrow lips, narrower than those of *K. seniradiatus*. This may rather be a representation of the morphological range of *K. seniradiatus*.

*Previous records.* Namurian of the southern Pennines (Neves 1961).

Genus CINCTURASPORITES Hacquebard and Barss 1957

*Type species. C. altilis* Hacquebard and Barss 1957.

*Remarks.* This genus includes specimens which have a cingulum and a distinct convolute ridge, or boss distal ornament. It is likely that the genus *Orbisporis* Bharadwaj and Venkatachala 1962 does possess an equatorial cingulum, although the authors do not describe such a feature; this, together with its variable distal ornament, makes it difficult to separate from *Cincturasporites*. Critical reassessment of the type material of the genus *Orbisporis* is necessary to resolve the problem.

*Cincturasporites intestinalis* sp. nov.

Plate 81, figs. 11–13; Plate 82, figs. 1–3

*Holotype.* MS132. Size 130 $\mu$.

*Diagnosis.* Over-all diameter 92–143 $\mu$, mean 104 $\mu$ (70 specimens); amb circular to sub-circular. Laesura distinct, straight, length two-thirds to equal to the central body radius, often gaping and frequently accompanied by a development of the proximal ornament. Cingulum from 10·0 to 19·0 $\mu$ in width, showing a poleward overlap onto the central body; the equatorial amb is irregular and has several thickened lobes. Cingulum is concentrically thickened, having a peripheral band of thickening and a further band adjacent to the body with a thinner area between. The distal and, to a lesser extent, the proximal faces of the central body are ornamented with convolute,

vermiform ridges, only rarely anastamosing, from 5·0 to 30·0 μ in length and 4·0 to 9·0 μ in width. The central body is most often displaced laterally.

*Remarks. Orbisporis convolutus* Butterworth and Spinner 1967 is similar but has a thickened band on the proximal side of the equator and lacks proximal ornament. *Cincturasporites* sp. Balme and Hassell 1962 seems to approach the structure of *C. intestinalis*.

Suprasubturma LAMINATITRILETES Smith and Butterworth 1967
Subturma ZONOLAMINATITRILETES Smith and Butterworth 1967
Infraturma CINGULICAVATI Smith and Butterworth 1967
Genus MUROSPORA Somers 1952

*Type species. M. kosankei* Somers 1952.

*Murospora intorta* (Waltz) Playford 1962

Plate 81, fig. 8

1938 *Zonotriletes intortus* Waltz, in Luber and Waltz, p. 22; pl. 2, fig. 24.
1954 *Simozonotriletes intortus* (Waltz) Potonié and Kremp, p. 159.
1956 *Simozonotriletes intortus* (Waltz) Ishchenko, pp. 88–9; pl. 17, fig. 204.

*Description.* Diameter 50–69 μ, mean 58 μ (30 specimens); amb subtriangular with straight to concave sides and rounded apices. Laesura simple, distinct, straight, length from two-thirds to equal to the spore body radius. Cingulum laevigate, 6–12 μ wide, may be thicker and wider at the apices, overlaps the central body on the proximal side.

*Remarks.* The validity of the generic assignment of this species remains in doubt. Staplin (1960) showed that *Murospora* Somers, *Simozonotriletes* (Naumova) Potonié and Kremp, and *Westphalensisporites* Alpern could be included in a single genus having patellate and capsellate forms, the equatorial feature being a tightly attached but separate part of the spore and not a centrifugal extension of the spore body. He did not amend the diagnosis of Somers. It is not known what is the true nature of the equatorial structure in the type material of *Simozonotriletes* and until this is understood the present specimens are placed in the genus *Murospora* following the work of Staplin.

EXPLANATION OF PLATE 81

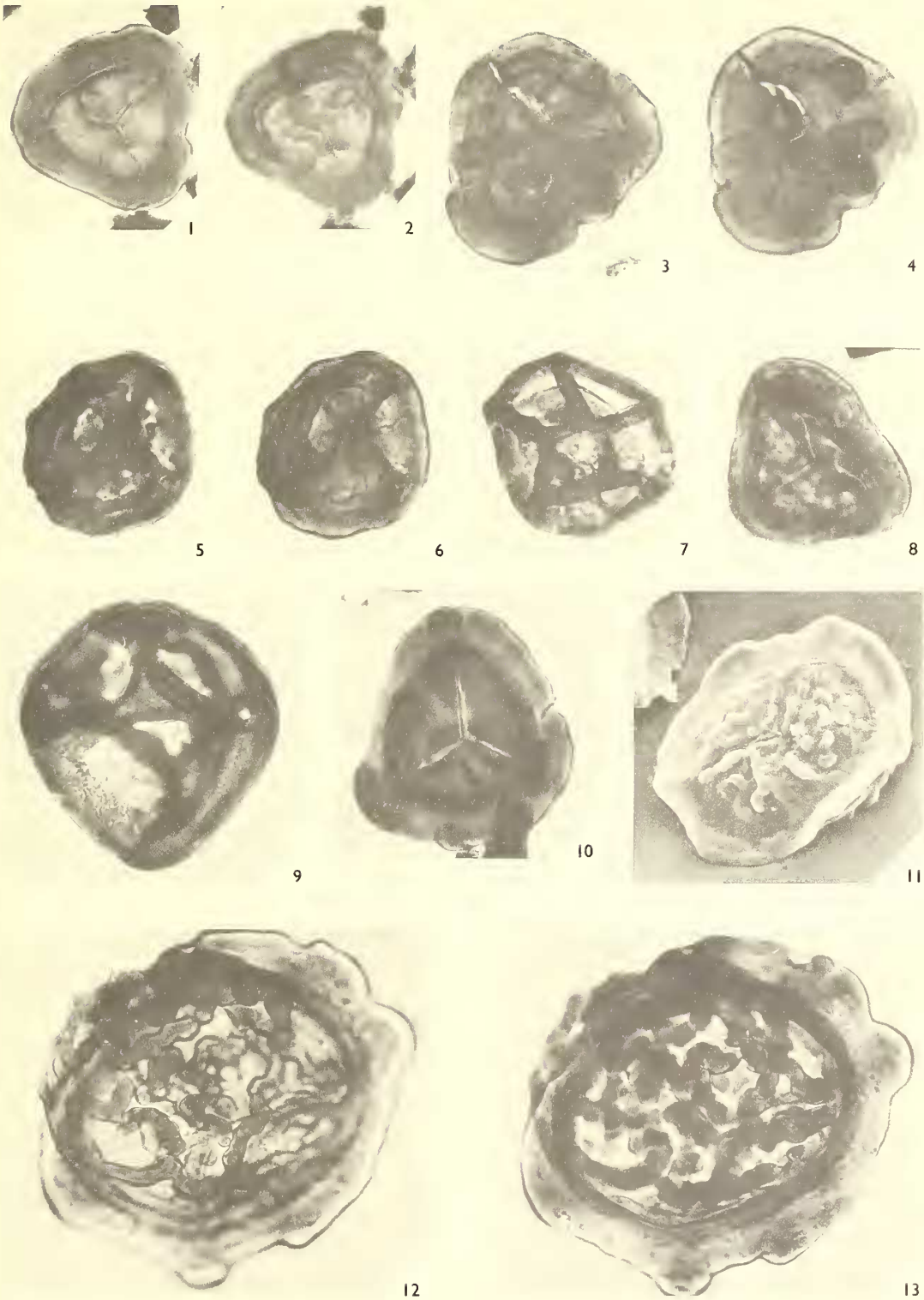
All figures × 500 unless otherwise stated

Figs. 1–4. *Lophozonotriletes muricatus* sp. nov. 1, Holotype, proximal surface; slide LC5b 46·7 101·4. 2, Holotype, distal surface. 3, Proximal surface; slide MS29. 4, Distal surface; slide MS29.

Figs. 5, 6, 7, 9. *Knoxisporites* spp. 5, 6, 9. *K. pristinus* Sullivan 1968. 5, Distal surface; slide MS26. 6, Proximal surface; slide MS26. 9, Distal surface; slide MS219. 7, *K. literatus* (Waltz) Playford 1962; Slide MS145.

Figs. 8, 10. *Murospora* spp. 8, *M. intorta* (Waltz) Playford 1962, Proximal surface; slide LC5a, 43·6 97·1. 10, *M. aurita* (Waltz) Playford 1962, Proximal surface; slide LC7b, 33·4 101·6.

Figs. 11–13. *Cincturasporites intestinalis* sp. nov. 11, Stereoscan, proximal surface; negative S/26/41, × 360. 12, Holotype, distal surface; slide MS132. 13, Holotype, proximal surface.




HIBBERT and LACEY, Early Carboniferous miospores

*Previous records.* Widely recorded from the Lower Carboniferous of the U.S.S.R. (Luber and Waltz 1938, Ishchenko 1956) and Spitsbergen (Playford 1962). The Upper Carboniferous of Britain (Sullivan 1958) and Upper Mississippian of Canada (Playford and Barss 1963).

### *Murospora aurita* (Waltz) Playford 1962

Plate 81, fig. 10

1938 *Zonotriletes auritus* (Waltz) in Luber and Waltz, p. 17, pl. 2, fig. 23.
1956 *Simozonotriletes auritus* (Waltz) Potonié and Kremp, p. 109.
1957 *Cincturasporites auritus* (Waltz) Hacquebard and Barss, p. 23, pl. 3, fig. 1.
1957 *Cincturasporites irregularis* Hacquebard and Barss, pp. 25–6; pl. 3, fig. 19.
1960 *Murospora varia* Staplin, p. 30, pl. 6, figs. 16, 18.
1960 *Murospora* sp. cf. *varia* Staplin, p. 30, pl. 6, fig. 19.
1962 *Murospora aurita* (Waltz) Playford, pp. 609–10, pl. 87, figs. 1–6; text figs. 6*a–q*, *s*, 7.

*Description.* Diameter 49–73 $\mu$, mean 59 $\mu$ (30 specimens); amb sub-triangular, margin smooth to undulating. Laesura distinct, straight, reaching to the equator of the central body, accompanied by lips 2·5–6·0 $\mu$ broad and slightly elevated. Cingulum from 5·0 to 13·0 $\mu$ wide, laevigate, showing variation in thickening and in equatorial outline, thickenings commonly situated at the radial apices.

*Remarks.* The overlap of the cingulum onto the central body is not considered to be a constant feature of *M. aurita* by Playford; he rejects the assignment to *Cincturasporites*. Certainly the continuous morphological series of cingulum width and thickness which he describes is present in the Basement Bed material, cingulum overlap occurring indiscriminately throughout this series.

*Previous records.* Lower Carboniferous of the U.S.S.R. (Luber and Waltz 1938, 1941). Upper Mississippian of Canada (Hacquebard and Barss 1957, Playford and Barss 1963). Lower Carboniferous of Spitzbergen (Hughes and Playford 1961, Playford 1962.)

## Genus LOPHOZONOTRILETES (Naumova) Potonié 1958

*Type species. L. lebedianensis* Naumova 1953.

*Remarks.* Potonié (1958) includes spores in the genus *Lophozonotriletes* which were cingulate and had a prominent verrucate ornament. Playford (1963*a*) found an overlap of the cingulum onto the central body in rather less than a half of the specimens of *Cincturasporites appendices* Hacquebard and Barss which he examined. He discounted this overlap and placed the specimens in *Lophozonotriletes*.

### *Lophozonotriletes muricatus* sp. nov.

Plate 81, figs. 1–4

*Holotype.* Slide LC5b, 46·7 101·4. Size 59 $\mu$.

*Diagnosis.* Over-all diameter 48–69 $\mu$, mean 58 $\mu$ (55 specimens); amb sub-triangular with convex sides and rounded apices. Laesura distinct, simple, straight, length from three-quarters to equal to the central body radius. Cingulum from 11·0 to 20·0 $\mu$ in

width. Distal surface of both the cingulum and the central body bears an ornament of verrucae which may coalesce to form ridges, from 3·4 to 7·5 $\mu$ in basal diameter.

*Remarks. L. appendices* (Hacquebard and Barss) Playford 1963, has an irregular distal ornament which is not elongate and is only rarely coalescent; it is also larger (110–70 $\mu$).

### Genus VALLATISPORITES Hacquebard 1957

*Type species. V. vallatus* Hacquebard 1957.

### *Vallatisporites vallatus* Hacquebard 1957

Plate 82, figs. 6, 13.

*Remarks.* The present specimens agree with the descriptions given both by Hacquebard 1957 and by Staplin and Jansonius (1964). There is a variability in the size of the vacuoles which are not considered by Staplin and Jansonius to be of secondary origin but rather as a specific character.

*Previous records.* Horton group (Tournaisian) of eastern Canada (Hacquebard 1957, Playford 1963). Banff formation (Tournaisian) of Alberta (Staplin and Jansonius 1964). Cementstone group (Tournaisian) of Ayrshire (Sullivan 1968).

### *Vallatisporites ciliaris* (Luber) Sullivan 1964

Plate 82, fig. 8

1938 *Zonotriletes ciliaris* Luber, in Luber and Waltz, p. 25, pl. 6, fig. 82.
1964 *Vallatisporites ciliaris* (Luber) Sullivan, p. 370, pl. 59, figs. 14, 15.

*Remarks.* Over-all diameter 52–77 $\mu$, mean 62 $\mu$ (50 specimens). The ornament described by Sullivan as galeae and spines is variable in size and density. In the present material there seems to be a continuous morphological series between this species and *V.* cf. *ciliaris* Sullivan 1964, in which the ornament is more or less completely absent. In this series there is considerable variation in the size and shape of the vacuoles.

*Previous records.* Drybrook Sandstone (Viséan) Forest of Dean Gloucestershire (Sullivan 1964). Bewcastle Beds (Upper Tournaisian/Lower Viséan) of north-west England (Butterworth and Spinner 1967).

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EXPLANATION OF PLATE 82

All figures $\times 500$ unless otherwise stated

Figs. 1–3. *Cincturasporites intestinalis* sp. nov. 1, Distal surface, slide MS69. 2, Proximal surface, slide MS69. 3, Stereoscan picture, distal surface, negative S/28/25, $\times 625$.

Figs. 4, 5, 7, 9–12. *Vallatisporites microgalearis* sp. nov. 4, Holotype, proximal surface, slide LC2a 23·5 102·2. 5, Holotype, distal surface, slide LC2a 23·5 102·2. 7, Distal surface, slide MS231. 9, Distal surface, slide LC2c 28·9 95·5. 10, Proximal surface, slide LC2c 28·9 95·5. 11, Stereoscan picture, distal surface, negative S/28/27, $\times 600$. 12, Stereoscan picture, proximal surface, negative S/28/26, $\times 600$.

Figs. 6, 8, 13. *Vallatisporites* spp. 6, *V. vallatus* Hacquebard 1957, Proximal surface; slide MS248. 8, *V. cilliaris* (Luber) Sullivan 1964, Proximal surface; slide MS233. 13, *V. vallatus* with *Lycospora uber*, stereoscan, proximal surface; negative S/26/2, $\times 650$.